

CONTINUED EVOLUTION OF EUROPA SUBSURFACE EXPLORATION TECHNOLOGIES

Frank D. Carsey, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109; fcarsey@jpl.nasa.gov,
Michael H. Hecht, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109; michael.h.hecht@jpl.nasa.gov,
Arthur Lonne Lane, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109; arthur.l.lane@jpl.nasa.gov,
Claus Mogensen, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, and University of Copenhagen, Copenhagen, Denmark, Claus.Mogensen@jpl.nasa.gov, and
Wayne Zimmerman Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109; wayne.f.zimmerman@jpl.nasa.gov.

The Galileo results convincingly indicate that Europa has a deep salty ocean covered by a shell of water ice a few tens of kilometers thick; this physical description gives rise to a host of thoughtful speculation as to the nature of the ocean, its seafloor, and the likelihood of microbial life within it. We argue that this situation points to the high desirability of a series of in-situ missions to examine the ice and, ultimately, the ocean. Given the chemical and physical changes that the surface has undergone from cosmic and solar fluxes, a useful in-situ mission should address the ice at a depth of at least 2 m; subsequent missions can reach the ocean. Clearly, subsurface in-situ exploration approaches are a crucial factor in making good progress answering Europa questions.

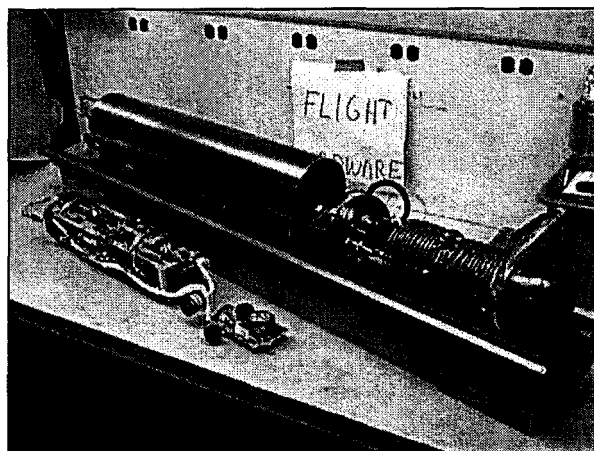
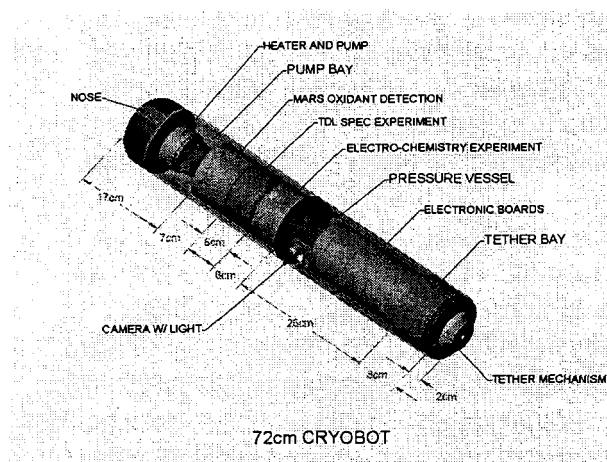
The development of technologies for subglacial mobility, scientific observations, and communications continues at JPL and other institutions. The goals of the research and development programs include the ice sheets of Earth (Group of Specialists 2002; Zimmerman et al 2001; Bay et al 2001; Carsey et al 2002), the north polar cap of Mars, and Europa. The technologies of interest are distributed among sensors and mobility platforms, and in both of these areas developments will greatly aid what can be done on a Europa subsurface mission. Europa exploration will rely on one technology area that has received insufficient attention, but it is an area in which the commercial device world has taken an interest, specifically devices to acquire and transfer microliter to nanoliter samples at high pressure and purity.

One glacial mobility approach is the thermal probe, e.g. Cryobot, that descends through ice by melting. The JPL Cryobot has recently undergone prototype field test (Zimmerman et al, 2002) in shallow ice in Svalbard, and the design has been updated for future projects in Greenland, Antarctica and the Mars North Polar Cap. The Mars Cryobot is interesting in that it represents the first effort at a miniaturized Cryobot, although it is by no means a design that we would propose for Europa. Issues that are impacted by miniaturization include the scientific instrument payload and the tether (or its substitute communications subsystem). Making the mobility platform smaller benefits the energy cost situation.

Cryobot instrumentation development suffers from some of the same ills as other extreme environment probes, specifically the combination of high pressure and constrained volume is challenging. In the particular situation of the Cryobot there are three distinct kinds of instrumentation:

- Instruments that obtain data while actually in the meltwater. A simple example is a thermometer; a more complex example is an electrochemical probe. The drawback of this approach is that the meltwater chemical characteristics are not local.
- Instruments that obtain data by taking in small volumes of meltwater, e.g. a mass spectrometer. This measurement system requires sample handling as well as exotic sample acquisition if the meltwater spatial averaging is to be overcome.
- Optical instruments, e.g., spectrofluorometers. These instruments are ideal from a deployment consideration. Light is directed into the ice or subglacial water body, and the material response is recorded by a camera or PMT; there are no plumbing issues.

In the last category, we are testing a dust sensor, designed with Earth ice sheets and the Mars polar caps in mind. It involves scattering of laser light from dust inclusions in the ice in the incidence angle range of 80°-125°; if possible, we will show data for this concept from Greenland ice in the National Ice Core Laboratory.



On the left the Mars Cryobot design; on the right the prototype Cryobot in assembly for the Svalbard test. On the table is the PC104 control stack and the camera. At far right the nose and pump bay with heaters clearly visible.

Bay, R., P. Price, G. Clow, and A. Gow, Climate logging with a new rapid optical technique at Siple Dome, Geophys. Res. Lett., 28, 4635-4639, 2001.

Carsey, F., H. Engelhardt, A. Lane, A. Behar, and V. Realmuto, A Borehole Camera System For Imaging The Deep Interior Of Ice Sheets, subm to Journ. Glac, in revision.

Group of Specialists, 2002, Report of the Subglacial Antarctic Lake Exploration Group of specialists (SALEGOS) Meeting, Bologna, Italy, 29-30 Nov., 2001 (avail <http://salegos-scar.montana.edu/>)

Zimmerman, W., F. Anderson, F. Carsey, P. Conrad, H. Engelhardt, L. French, and M. Hecht, The Mars '07 north polar cap deep penetration Cryoscout mission, IEEE Aerospace Conference, Big Sky, Montana, Session 2.07, 2002.